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steel interchange

Transverse Stiffeners as Stability Bracing

It seems that full-depth transverse stiffeners prevent relative movement of a beam's flanges. Can the location of transverse stiffeners in a beam be considered a brace point?

We receive this question on a regular basis. The answer is no. Transverse stiffeners are simply along for the ride as the section rotates and provide no resistance to lateral-torsional buckling on their own. As a result, they do not affect the unbraced length of the beam, L_b. Stiffeners can be used to reduce the web deformation and improve the efficiency of torsional braces. However, used alone, web stiffeners are ineffective in enhancing the stability of members.

Bo Dowswell, PE, PhD

Mill Orders

Are there published criteria or requirements for a steel mill order package?

No. There are published documents, such as Sections 107 or 1603 of the 2015 *IBC* and Section 3 of the AISC *Code of Standard Practice for Steel Buildings and Bridges* (a free download from **www.aisc.org/code**), which give requirements for information to be included in the final "for construction" documents, but a "steel mill order" or a "steel fabrication package" are partially developed packages negotiated on a project-by-project basis to provide information to the contractor.

For better or worse, it has become quite common for an owner or contractor to request an early release steel package in advance of the final "for construction" documents. Different clients, owners, contractors, fabricators, erectors, architects and engineers often have different expectations with regards to what that means with respect to the level of detail that should be included in the design documents. Ideally, there should be a dialogue between the design team and the construction team to clearly define the intent of the early package and the information that should be included prior to releasing the design documents. In my experience, I have seen the phrase "mill order" used generically to describe a broad spectrum of deliverables—from something that simply allows a fabricator to reserve material from a mill roll all the way up to structural drawings that have sufficient detail to allow shop drawing production to occur.

While the phrases "steel mill order" and "steel fabrication package" do not have standard definitions, in my mind a mill order package should provide the fabricator sufficient information to interface with the steel mill and establish an advanced bill of material purchase. This would include primary member sizes, member material designations and the geometry defined with enough detail to establish individual member lengths.

Given all this, when a request is made for a structural designer to issue an early steel package under any name—early package, mill order, fabrication package, etc.—the designer should seek clarification as to the intended use of the package and adjust accordingly.

Susan Burmeister, PE

Stability Bracing for Members Other Than Wide-Flange Members

When checking relative bracing for a beam Equations A-6-5 and A-6-6 of the AISC *Specification*, Appendix 6 includes the term h_o, the distance between the flanges centroids. When checking bracing requirements for a tee, what value should be used for h_o?

The *Specification* does not address that condition, so you will have to use your own engineering judgment. I will provide some further information to assist you.

Appendix E of AISC Design Guide 28: *Stability Design of Steel Buildings* (a free download for members from **www.aisc.org/dg**) provides background related to the stability bracing requirements beyond what is included in the Commentary to the *Specification*.

Stability is very important, and for typical members it is not difficult to provide. The adequacy of the vast majority of member stability bracing is commonly judged by inspection. Stability concepts can be traced pretty far back into the history of steel design. However, their explicit presence in the *Specification* is fairly recent. For example, the 1986 *Specification* (the first LRFD specification) states: "The stability of individual elements must also be provided." And this appeared in the Commentary. It did point to other resources as well: "Considerable attention has been given to this subject in the technical literature, and various methods of analysis are available to assure stability. The SSRC *Guide to Design Criteria for Metal Compression Member* devotes several chapters to the stability of different types of members considered as individual elements, and then considers the effects of individual elements on the stability of the structure as a whole."

None of this directly helps you with your issue. However, it may help you feel a sense of relief that although it is possible to provide insufficient bracing, it is usually apparent that you may have done so.

In your case, all you need to recognize is that the moment is an indirect measurement of the force you are actually bracing against. You do not need h_o—it is a means to an end. Equation C-A-6-5 in the *Specification* Commentary provides a more direct perspective. You are evaluating the bracing against the compressive force in the flange, not the moment in the beam. The Commentary states: "(C_bP_f) can be approximated by M_r/h_o." All of the discussion I have cited relates to stiffness checks, but the basic ideas apply equally to strength.

One issue that sometimes gets overlooked is that the stiffness equations assume one end of the brace is attached to something very stiff. A W14×730 can be a brace but if one end attaches to the face of a piece of sheet metal, it still may not have sufficient stiffness. Though shown relative to a different condition, Equation C-A-6-12 illustrates how to calculate the stiffness of a series of elements. Again, I suspect explicit checks are rarely performed after one is familiar with the usual results from the checks provided in the *Specification*, but it is good practice to look at both ends of whatever you are assuming to be a brace.

Larry S. Muir, PE

Transverse Reinforcement of Composite Beams at Edge Conditions

We are investigating the need for transverse reinforcing over composite beams and have noticed that some foreign standards have specific requirements for additional transverse reinforcement. These seem to apply at spandrel beams near the edge of the slab. We can find no similar requirements in the AISC *Specification* and are curious as to how the AISC *Specification* considers edge conditions.

We can only comment on requirements set by the AISC *Specification*. Relative to edge conditions, the Commentary to the *Specification* states:

"The use of edge distances in ACI 318 Appendix D (which is now ACI 318 Chapter 17 in the reorganized version) to compute the strength of a steel anchor subjected to concrete crushing failure is complex. It is rare in composite construction that there is a nearby edge that is not uniformly supported in a way that prevents the possibility of concrete breakout failure due to a close edge. Thus, for brevity, the provisions in this *Specification* simplify the assessment of whether it is warranted to check for a concrete failure mode. Additionally, if an edge is supported uniformly, as would be common in composite construction, it is assumed that a concrete failure mode will not occur due to the edge condition. Thus, if these provisions are to be used, it is important that it be deemed by the engineer that a concrete breakout failure mode in shear is directly avoided through having the edges perpendicular to the line of force supported, and the edges parallel to the line of force sufficiently distant that concrete breakout through a side edge is not deemed viable."

The research cited in the Commentary (Pallarés and Hajjar, 2010a, 2010b) also asserts such restraint commonly exists, but does not clarify the basis for this. AISC Design Example I.2 clarifies, stating: "The slab edge is often uniformly supported by a column flange or pour stop in typical composite construction, thus preventing the possibility of a concrete breakout failure and nullifying the edge distance requirement as discussed in AISC *Specification* Commentary Section I8.3." Design Examples are a free download at **www.aisc.org/manualresources**.

The User Note in Section I8.3 again points to this sort of restraint, stating: "If concrete breakout strength in shear is an applicable limit state (for example, where the breakout prism is not restrained by an adjacent steel plate, flange or web), appropriate anchor reinforcement is required for the provisions of this Section to be used. Alternatively, the provisions of the applicable building code or ACI 318, Appendix D may be used."

Larry S. Muir, PE

Eccentric Stability Bracing

I have a wide-flange beam attaching near the face, as opposed to the center, of an HSS column. Can the beam be assumed to be a lateral brace in the design of the column?

The brace must have adequate strength and stiffness, as required by Appendix 6 of the AISC *Specification*. A complicating factor is the location of the brace point. The equations in Appendix 6 were developed assuming the brace acts at the column shear center.

There are two ways to account for the brace being off-center:

1. Design based on the assumption that the brace point is located at the column centroid. The connection must have adequate strength and stiffness to accommodate this assumption, based on calculations or judgment.
2. Check the column for constrained-axis buckling. Constrained-axis buckling is discussed on Page 36 of AISC Design Guide 25: *Frame Design Using Web-Tapered Members* (a free download for members from **www.aisc.org/dg**). The theory behind the equation is in the classic book *Theory of Elastic Stability* by Timoshenko and Gere. For wide-flange shapes, design examples and tables were developed by Liu et al. (2013). Because HSS sections are very stiff in torsion, and therefore constrained-axis buckling, this may be the best option.

Reference:

Liu, D., Davis, B., Arber, L. and Sabelli, R. (2013), "Torsional and Constrained-Axis Flexural-Torsional Buckling Tables for Steel W-Shapes in Compression," *Engineering Journal*, AISC, Fourth Quarter. *Engineering Journal* papers can be downloaded from the AISC website at **www.aisc.org/ej**.

Bo Dowswell, PE, PhD

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